ENVIRONMENTAL QUARTERLY

In This Issue...

Steam Jets as vacuum pumps for altitude chambers

♦

Test facilities for handling liquid oxygen

♦

IEE Announces Program of First Annual Meeting

♦

In a future issue...The Glenn L. Martin Company scraps an altitude-temperature-humidity chamber, and writes specification for its replacement.

Letters to the Editor

Dear Sir:

Aircraft Radio Corporation has recently constructed a new engineering building which includes a relatively complete Environmental Test Laboratory. During the planning for this laboratory, the problem of high frequency vibration system requirements arose and, even now, is still under consideration.

Thus, the article "Vibration Testing for the Neophyte" by Mr. Robert L. Stallard (Environmental Quarterly, 4th Quarter 56) was quite timely for it presented in a very concise, complete and unbiased manner most of the pertinent information on high frequency vibration systems.

Please continue inclusion of similar articles which would help to explain to "the neophyte" the necessity for and the requirements of other phases of environmental testing.

R. A. NEWELL
Supervisor, Environmental Test. Dept.
Aircraft Radio Corporation

Dear Sir:

The interim [explosion] test procedure to MIL-E-5272 issued by this Center specified that the test temperature

(Continued on Page 24)

Shaker system for complex motion tests

Newest technique in environmental testing is complex motion testing.

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Circle 701 on Page 20.

A Policy For Controversy

Editorial

We aspire to make the Environmental Quarterly ser as a free forum with regard to technological subjects of controversial nature. We shall welcome the opportuni to present ideas that may arouse contradiction, for only this fashion can we approach the usefulness for whic we strive.

We shall go beyond the practice of the "free exchan of knowledge" so admirably carried on in the Unite States to encourage debate between men of conflicti opinions. The truth that we all seek is better and fast revealed when men of good-will throw the light of wh *they* know into the shadows of other men's ideas and fiel of knowledge and thus by the combination bring all co cerned more quickly to a new understanding. In the d velopment of ideas, as in the development of animals a plants, "cross-fertilization" leads to strength.

And this brings us to a case in point. In the article page 4 dealing with the application of steam jects to t problems of evacuating high-altitude chambers, M Bykowski implies in his opening paragraphs that t various forms of rotary pumps are not altogether adequa for the requirements of todays altitude chambers. W have discussed this matter with the chief engineer of manufacturer of altitude chambers and have his stat ment that his company has several large chambers in t field where rotary single-stage vacuum pumps achieve alt tudes in excess of 100,000 and even 120,000 feet. We e pect to print a formal commentary from this expert the subject in the next issue of the Quarterly.

R.H.M.

IN A FUTURE ISSUE

The Glenn L. Martin Company is scrapping an obsolete and worn-out altitude-temperature-humidity chamber. In a future issue the ENVIRONMENTAL QUARTERLY will carry an article covering this Martin experience. It will be filled with concrete and useful material: troubles and faults of the old chamber, salvage attempts, the decision to scrap, writing specifications for the replacement, how size and ranges of capabilities were determined, etc.

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Vol. 3, No. 1 First Quarter 1957

ENVIRONMENTAL QUARTERLY

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Ray H. Mattingley, Editor

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Steam Jet Vacuum Pumping for Large Altitude Chambers 4
by Ronald M. Bykowski
The author advocates steam jets as altitude simulators, especially for the future.

IEE Announces Program of First Annual Meeting 2
A distinguished group of speakers will present papers before environmental engineers and scientists of the United States, Canada, and other countries. EEI Equipment Conference to be held concurrently.

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Designing Test Facilities for Liquid Oxygen 10
by Norman Meyers

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The *Environmental Quarterly* is circulated to men concerned with environmental simulation and testing in industry, Government and our universities. It is the only magazine devoted exclusively to environmental science, simulation, and testing.

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INSTITUTE OF ENVIRONMENTAL ENGINEERS

Announces

FIRST ANNUAL TECHNICAL MEETING

to be held with an

Equipment Conference for the Environmental Equipment Institute

Since space is limited, attendance at some meetings must be restricted. Registrations are to be accepted in the order received at Institute Headquarters.

Mr. Henry F. Sander, Provisional President of the IEE, has formally announced the program for the First Annual Technical Meeting of the Institute at the La Salle Hotel, Chicago, Illinois, on April 25th and 26th, 1957. Simultaneously, Mr. Charles E. Earl, President, EEI, announced an Equipment Conference for the Environmental Equipment Institute on the same dates at the La Salle Hotel.

According to Dr. George D. Wilkinson, General Manager of both the IEE and the EEI, over three thousand preliminary announcements of the April meeting have been sent to selected individuals throughout the United States and Canada. Dr. Wilkinson stressed the basic fact of space limitation at the meeting and urged early registration. A vast number of straws in the wind and concrete inquiries indicate a tremendous interest in the coming meeting, Dr. Wilkinson said.

The formal program for the April meeting is to be printed and distributed at the end of March. The preliminary announcement of the program is presented below, together with abstracts of the papers.

WEDNESDAY, APRIL 24th

Registration:

7:00 P.M. to 10:00 P.M.

THURSDAY, APRIL 25th

Registration

(18th Floor Foyer): 9:00 A.M. to 11:45 A.M.

Facility Trip I: **BASIC NUCLEAR RESEARCH LABORATORY at the University of Chicago**

Its low-temperature laboratory is one of the two largest installations in the United States.

9:00 A.M. to 11:30 A.M.

Session A **(Lincoln-Douglas Room): "AIR FORCE EXPLOSION TESTING TECHNIQUES" by G. W. Gerhardt, Wright Air Development Center**

"QUALIFICATION TESTING OF HIGH TEMPERATURE AIRCRAFT HYDRAULIC PUMPS" by A. B. Billett, Vickers, Inc.

With the advent of Jet Engine Aircraft and its continued development for higher performance have come numerous problems in the qualification testing of hydraulic components. These new problems center largely around temperatures of 275°F. to 550°F.

Session B **(Illinois Room): "SINUSOIDAL, RANDOM, AN SINUSOIDAL PLUS RANDOM EXCITATION" by F. Geor General Electric Corporation**

Five phenolic wiring boards of varying areas were subject to sinusoidal, random, and sinusoidal plus random excitatio The vibratory response was sensed by accelerometers plac identically on all boards for the different types of excitatio Actual test results will be analyzed and conclusions presente

"ENVIRONMENTAL TESTING WITH RANDOM NOI VIBRATION" by D. G. Douglas, Rocketdyne Division of Nor American Aviation

Laboratory tests of rocket engine components subjected an environment of random noise vibration will be discussed. procedure whereby an engineer may determine the operation response of non-linear elements to vibration.

Equipment Conference **(Century Room): Members of t ENVIRONMENTAL EQUIPMENT INSTITUTE will be ava able to discuss test equipment.**

12:00 Noon to 2:00 P.M.

Luncheon **(Grand Ball Room): Welcoming address Charles E. Earl, President Environmental Equipment Institu and H. F. Sander, President Institute of Environmental Enginee**

2:30 P.M. to 5:00 P.M.

Session C **(Linclon-Douglas Room): "HIGH ALTITUD MISSILE GUIDANCE EQUIPMENT TESTED ON TH GROUND" by P. H. Brandt, Murphy & Miller, Inc.**

Altitude 120,000 feet, temperature 110° below zero. The pr lems of simulation and instrumentation.

"RAM AIR SIMULATION DURING TEMPERATU ALTITUDE TESTS" by Dr. Neal A. Cook, Westinghouse A Arm Division

The difficulty of performing temperature-altitude tests non-pressurized electronic equipment while maintaining i ternal cooling from an external source.

Session D **(Illinois Room): "HIGH TEMPERATUR VIBRATION MEASUREMENTS" by W. R. Elliot, Boeing A craft Corporation**

Means of calibrating vibration transducers up to 1,000°F. a presented. Two test facilities, one which has an upper limit 600°F. and another that is capable of vibration testing up 1,000°F. will be described.

"PREDICTING & EVALUATING LOW FREQUENC VIBRATION ENVIRONMENTS OF AIRCRAFT" by E. Kirchman, Glenn L. Martin Company

The problems associated with low-frequency vibration, condition characteristic of aircraft structure, will be discuss A typical environmental spectrum developed and the effects equipment design, isolator requirements, and environmen testing techniques will be evaluated.

"WHAT TO DO WHEN IT'S TOO BIG TO TEST" by R. M. Mains, Knolls Atomic Power Laboratory

As an alternative to bigger and even bigger test equipment, various constructive steps that can be taken short of complete simulation are to be discussed. An example is offered in terms of the reactor compartment of a nuclear powered submarine. The need for better definition of damage criteria is emphasized, so that tests and calculations have more meaning.

Equipment Conference (Century Room): 8:00 P.M. to 10:30 P.M.

Open House (Century Room). Sponsored by members of the Environmental Equipment Institute and others of the Equipment Conference.

FRIDAY, April 26th

Registration
(18th Floor Foyer)

9:00 A.M. to 11:45 A.M.

Facility Trip II: BASIC RESEARCH LABORATORY at the University of Chicago

9:00 A.M. to 11:30 A.M.

Session E (Chicago Room): "PROBLEMS OF HUMIDITY INSTRUMENTATION" by J. Boyle, Boyle Engineering Laboratory

Relative humidity, and precision in measuring humidity and other parameters.

"DESIGN CONSIDERATION FOR ADVANCE PERFORMANCE TEMPERATURE, HUMIDITY AND ALTITUDE PARAMETERS IN A TEST FACILITY" by B. Friedman, Tenney Engineering, Inc.

This paper will cover a forced-air system that provides less than 10° gradient at 350° F. and at 80,000 feet.

Session F (Lincoln-Douglas Room): METHODS FOR ESTIMATING ACOUSTIC ENVIRONMENT FOR THE B-5b WEAPONS SYSTEM" by E. H. Stepp, Convair

Example of the predicted acoustic environment of the airframe structure and electronic subsystem will be presented.

"SOME RESULTS OF STRUCTURAL TESTS UNDER HIGH INTENSITY NOISE" by H. H. Hubbard, National Advisory Committee for Aeronautics

Description of characteristics of the intense noise field encountered near aircraft power plants. Recounting of experience in testing to destruction of simple panels with both discrete and random type noise loading. These tests revealed some of the effects of panel thickness, curvature, and edge conditions, as well as internal pressure. The behavior of panels subjected to noise loading is to be illustrated by means of high-speed motion pictures.

"PROBLEMS IN ACOUSTICALLY INDUCED EQUIPMENT FAILURE" by Dr. I. Dyer and Dr. J. Baruch, Bolt, Beranek and Newman, Inc.

An outline of the basic problems assumed to be involved in the failure of electronic equipments under high intensity sound.

Equipment Conference (Century Room): 12:00 Noon to 2:00 P.M.

Luncheon (Grand Ballroom). SPEAKER: Dr. Alan E. Surosky, Manager of Manufacturing, Nuclear Development Corporation of America, "Propulsion Reactors and their Environments."

2:30 P.M. to 4:30 P.M.

Session G (Chicago Room): "EFFECTS OF A HETEROGENEOUS GROUP OF FUNGI ON MILITARY EQUIPMENT AND MATERIAL" by Dr. E. J. Keegan, St. Johns University

A short history; physiology and nutritive requirements; effects of sub-zero temperatures; and various microbial defects in relation to Fungus Testing.

(Continued on Page 15)

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Steam Jet Vacuum Pumping for Large Altitude Chambers

Ronald M. Bykowski, Cornell Aeronautical Laboratory

Steam jets have the outstanding characteristic of large-volume capacity at low pressures. This, combined with the advantages of lower first cost, lower maintenance cost, ruggedness, compactness, and ease of operation, makes them eminently suited for use as altitude simulators.

In a previous article in the *Environmental Quarterly*[1], Mr. David Ettelman explained that rotary vacuum pumps are the most practical of the available mechanical devices for simulating altitudes.

Some authorities[2,3] claim, however, that rotary pumps —sliding vane, lobe, and revolving liquid—are ordinarily limited to practical suction pressures equivalent to something in the order of 40,000 feet in single-stage operation and 70,000 feet in two-stage operation.

If this claim is true, then, in the light of present operational altitudes of military aircraft, these limits are borderline today and are certain to be inadequate for the future.

In a large chamber where significant leakage exists or where equipment is being tested that requires large quantities of make-up air for combustion or cooling, a rotary pump might be incapable of maintaining the pressure equivalent of high altitude. A rotary pump is essentially a constant displacement device, and the mass flow of gas through it decreases directly with the gas density. When a high mass flow of gas is required, the installation of parallel units is a necessity, and this is not only costly but space-consuming.

Under these conditions, the designer should consider the use of steam jet ejectors as vacuum pumps. Although a feasible arrangement would be to use a rotary-pump-steam-ejector combination, I have limited this discussion to the use of steam ejectors alone.

Steam jets have the outstanding characteristic of large-volume capacity at low pressures. This, combined with the advantage of lower investment, lower maintenance costs, ruggedness, compactness, and ease of operation, makes them highly suited for use as altitude simulators.

Mr. Bykowski is an Associate Research Engineer in the Altitude Chamber Branch, Wind Tunnel Dept, at CAL. He received the Bachelor of Science degree in mechanical engineering from the University of Delaware in 1950.

A single-stage steam jet can simulate an altitude o 60,000 feet, and a two-stage jet is capable of 100,000 fee Three-, four- and five-stage jets are common in th chemical industry and operate down to suction pressure as low as .003 inches of mercury.

Principles of the Steam Jet

Steam jets are compressors. They convert the pressur energy of the motive steam to high-velocity energ through the jet nozzle (Fig. 1). This high-velocity stea entrains the air or other gas in the suction port and th resultant mixture enters the diffuser, where the velocit energy is converted back into pressure. For a given stea pressure and pressure ratio, the minimum suction pre sure that can be obtained is a constant. The airflow* that can be maintained is directly proportional to th steam flow. Therefore, only the size of the units (orific and diffuser areas) is increased as more airflow i required.

A single-stage jet can be designed to obtain altitude of more than 60,000 feet at shut-off, that is, at zer airflow. Designers of altitude chambers, however, wil probably be interested in higher altitudes, which ar obtained by operating two or more units in series. A two-stage jet system is capable of simulating an altitud of 100,000 feet. I believe that the two-stage system i ideal for altitude chamber application, and the rest o this article is devoted to it.

Condensing or Non-Condensing

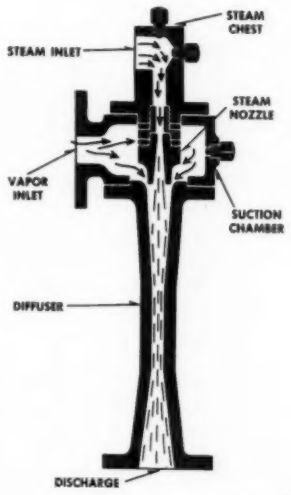
Two-stage jet pumps can be designed as condensin and non-condensing. In a condensing system (Fig. 2 the discharge of the first stage enters an intercondense where water condenses the first-stage steam and coo the suction air. This reduces the load on the secon stage, and compression can be done with less stea The intercondenser can be either a surface type o direct-contact barometric type. Barometric condense usually require less steam and less cooling water tha

**I have used the term "airflow" for convenience although oth gasses than air may be involved, for example, moisture-vapor or t gasses occurring in processes using petro-chemicals.*

surface condensers. However, a disadvantage is that the direct-contact condensers require an elevation of at least 34 feet on the units to eliminate the possibility of flooding the system. I do not recommend a condensate pump used on a low-level direct contact condenser.

In a non-condensing system the discharge of the first stage is connected directly to the suction of the second stage. The first cost of a non-condensing system is much lower because no inter-condenser or cooling tower system is required, although there are techniques for providing cooling water without the use of a cooling tower. However, operating costs are higher because the second stage has to carry the first stage steam in addition to the gas, resulting in a higher steam rate.

A condensing system is generally more stable in operation and requires less attention by the operator. The non-condensing system requires less space and can be installed in a more accessible location. The final decision on whether to condense or not is made by balancing the factors of available investment money, steam cost, steam availability, and operability. Another critical factor is the number of hours usage in the altitude range where staging, and thus the increased steam flow, is necessary.

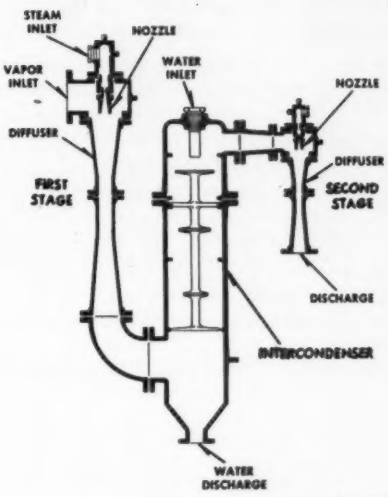


Courtesy the Elliott Co.

Figure 1. Functioning of the steam jet ejector.

Factors Affecting Airflow

The gasload on a vacuum pumping system in an altitude chamber is the leakage rate into the chamber plus the number of pounds of make-up gas required for test purposes. With careful design, leakage in a high altitude chamber can be kept to between 10 and 20 pounds per hour. The temperature and molecular weight of the gas removed must also be considered when sizing ejector units. The weight flow is affected by temperature, humidity, and combustion products.



Courtesy the Elliott Co.

Figure 2. Two-stage steam jet pump designed as part of a condensing system.

Flow versus Altitude

Flow characteristics of specific steam jet systems are shown in Figure 3. Curve 1 shows the performance of a single-stage jet alone. Curve 2 shows the performance of a low-vacuum jet in series with the jet of Curve 1. Actually, the manufacturer has considerable latitude in designing systems, especially in the characteristics of the first-stage jet. Characteristics as shown in Curves 3 and 4 are also available. Notice that airflow capacity is sacrificed to obtain higher altitudes.

In design, the best practice is to specify the airload at a given suction pressure or pressures based on chamber test requirements. This information will enable the manufacturer to choose the type and size of jets necessary. If a system such as Curves 1 and 2 is choosen, the units are sized to obtain the desired flow. The shape of the characteristic remains the same as in Figure 3, and only the ordinate changes, depending on the steam flow required.

Figure 4 shows a typical design that has been proposed for the Cornell Aeronautical Laboratory altitude chamber. In this case, the second stage comprises two parallel jets of equal capacity. One half of the second stage will be used alone (Curve 1) for tests at lower altitudes requiring less flow. For tests at lower altitudes requiring more flow, boh units are used (Curve 2). For higher altitudes, the staged system is used (Curve 3). This splitting up of the second stage allows more operational flexibility and steam economy. The increased cost for an extra jet is small and is soon recovered in steam savings.

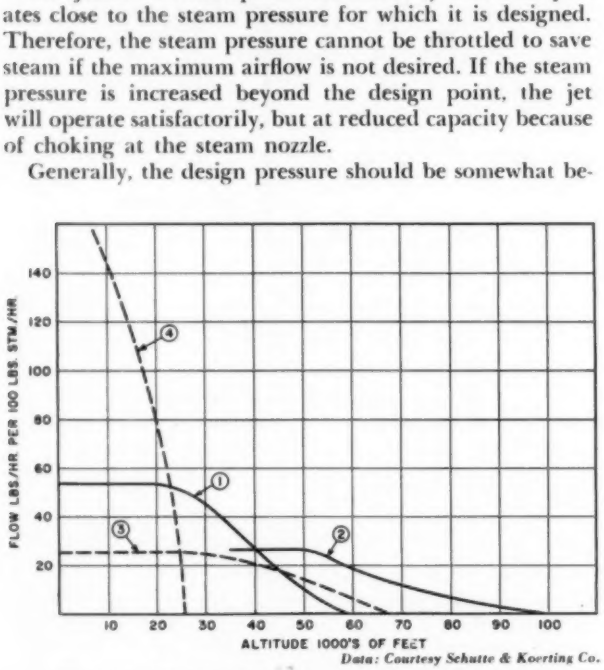
Of course, when a second-stage jet is used alone, no condensing water is required. At altitudes lower than that corresponding to point A, a single-stage jet should always be used. The combination of ejectors just satisfying the test flow conditions required should be used when operat-

ing between the altitudes corresponding to points A and B. The area under the extremities of these performance curves represents the operating area of the altitude chamber.

Steam Pressure

An ejector will not operate satisfactorily unless it operates close to the steam pressure for which it is designed. Therefore, the steam pressure cannot be throttled to save steam if the maximum airflow is not desired. If the steam pressure is increased beyond the design point, the jet will operate satisfactorily, but at reduced capacity because of choking at the steam nozzle.

Generally, the design pressure should be somewhat below the lowest steam pressure that will be encountered. Normally, design steam pressure should not be below 90 psig. Systems can be designed with steam pressures as low as 60 psig, but higher than normal steam rates are necessary. The higher the design steam pressure, the lower the steam rate. Dry, saturated steam is required, but superheat does not improve economy.



Data: Courtesy Schutte & Koerting Co.

Figure 3. Characteristics of specific steam jet ejectors.

Design

Figure 5 shows the essentials of a suggested design for a two-stage, condensing system. Altitude control is effected by automatic control of the bleed-back rate of steam from the discharge to the suction. Throttling of the suction line is feasible, but finer control is possible with the bleed-back system, and the pressure drop of the throttling valve is eliminated.[4] Manually set, pneumatic-operated control valves are used in the steam supply lines to each ejector. These valves allow automatic panel control of ejector staging and are also used to throttle the steam slightly to correct for variations in supply steam pressure. Tight shut-off check valves are required in the second-stage discharge lines to prevent by-passing and to hold altitude in the chamber without steam flow.

A silencer is desirable in the discharge line to reduce the noise from the discharging steam and air. Care must be taken that the back pressure on the ejectors does not exceed 1 psi. An after-condenser is an excellent silencer and eliminates the steam discharge but is probably not justified except where cooling water is easily obtainable. All steam supply and discharge lines must be properly sloped and trapped to remove condensate.

The optimum location of the cooling tower depends upon the physical setup. The schematic implies a roof location for the ejector and the cooling tower, This will usually provide the necessary elevation for the barometric leg. If the cooling tower is also installed on the roof, an additional pump to supply the water to the condenser is unnecessary. The partial vacuum in the intercondenser will draw its own water once the condenser has been "primed." The by-pass line on the recirculating pump is provided for this purpose. The control valve in the water supply line to the intercondenser is used to control flow and thus the temperature of the condenser water. Accurate control of the condenser water temperature stabilizes the ejector operation. If the cooling tower is placed in another location, care must be taken to insure that the flow of water to the tower is balanced with that flowing to the condenser.

Costs

Figure 6 shows the approximate cost versus capacity at 75,000 feet altitude for non-condensing and condensing systems. The cost figures shown are for the ejector system proper only. This does not include piping, cooling tower or controls. A complete, installed two-stage system with barometric intercondenser would be about 8 to 10 times the cost shown, while a two-stage, non-condensing system would cost about 4 to 6 times as much.

Operating costs of a condensing jet ejector system (primarily steam costs) are less than the cost of electric power driving motor and compressor sets that deliver the equivalent capacity. The steam rate in a non-condensing system is almost double that of an equivalent condensing system.

Maintenance

Maintenance costs for steam jets are much lower than for other types of vacuum pumps. No lubrication or adjustment is necessary. There are no moving or wearing

(Continued on Page 14)

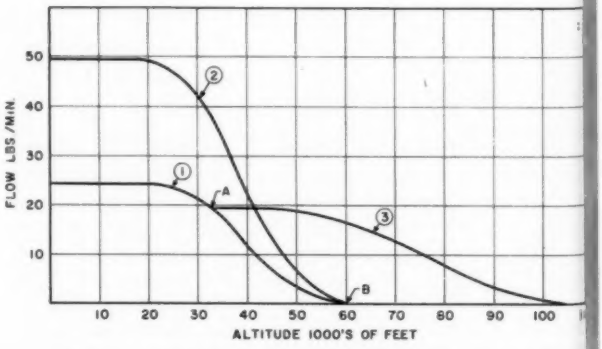


Figure 4. Typical steam jet ejector performance curves.

Questions and Answers

We invite you to send us questions suitable for publication in this department, and to send us solutions to problems posed by other peoples' questions.

Here is last month's question, to which we have received no answers:

Dear Sir:

In the design of a high temperature walk-in chamber, a problem has been encountered with bearing lubrication. The design of the chamber is such as to require mounting the bearings inside the chamber where the air temperature is between +500°F and −100°F with an altitude of 100,000 feet.

The question is — does anyone know of a lubricant which will retain its lubricating qualities to +550°F, still have reasonably low torque at −100°F, and be unaffected by the combination of high altitude and high temperature?

H. C. Jones, Sr. Engr.
Environmental Test Section
Air Arm Div.
Westinghouse Electric Corp.

Can You Answer This One?

Dear Sir:

I'm wondering if you can help us with a problem concerning operational personnel for high or low temperature walk-in chamber.

Several sources have recommended maximum personnel exposure times in these chambers and maximum frequency intervals.

Could you tell us where and how to obtain any legal or medical rulings on this problem?

C. G. Stradling
Kearfott Company, Inc.

NOTE: Please address replies to this and to last month's question to the attention of the editor.

IEE First Annual Meeting, La Salle Hotel, Chicago, April 25 and 26. Program announcement on page 2. Hotel reservation card enclosed with this issue of the quarterly.

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Circle 711 on Page 20.

NEW STANDARD ATMOSPHERE ADOPTED —

TO ONE MILLION FEET

WILLIAM A. SCHOLL
Environmental Criteria Branch
Wright Air Development Center

Down through the years almost everyone working with atmospheric properties in the United States has made use of he NACA (National Advisory Commitee for Aeronautics) Report 218, "Standard Atmosphere – Tables and Data," by Walter S. Diehl. Other countries of the world also adopted arbitary standard atmospheres, and for many years no difficulty resulted from this situation.

With the advent of international air travel, problems arose. For example, instruments calibrated to different standards gave varied readings that could have resulted in dangerous flight conditions, and thus in 1952 the ICAO (International Civil Aviation Organization) adopted a Standard Atmosphere* to be used by all participating nations. The ICAO Standard Atmosphere differs but slightly from the NACA Standard, but since it *does* differ the long-accepted Standard must give way to the one which, by agreement, is acceptable to many nations.

In June 1953, the Air Research and Development Command instructed the Air Force Cambridge Research Center, in coordination with the Wright Air Development Center, to establish standard and model amosphere tables to meet the needs of the Air Force. These tables were to be consistent with the then newly adopted ICAO Standard Atmosphere Tables.

In July 1953, organizations and individuals actively interested in upward extensions of the standard atmosphere were invited to attend a meeting at the Cambridge Research Center in October 1953 for the purpose of organizing a group of civilian and military engineers and scientists that would meet periodically for approval of such extensions.

The list of organizations that sent representatives is long and impressive and included:

Air Research and Development Command; Air Weather Service, MATS; Ballistics Research Laboratory, Army Proving Ground; Harvard College Observatory; ICAO; NACA; National Bureau of Standards; Naval Research Laboratory; The Rand Corporation; etc.

Working Group Formed

A small working group was selected and was asked to make recommendations to the parent group for an extension above 20 kilometers of the standard atmosphere to include:

Maximum Height to which the standard would be extended. (Tentative extensions above the level of recommended standardization were to be included.)

Temperature-height curve.

Type of vertical ordinate.

Height intervals.

Parameters.

Physical constants to be used in computing the parameters, dependent upon the temperature-height curve.

Constants for conversion from English to metric units.

Appendices to be included to increase the value of the standard to the users, such as deviations, extremes, etc.

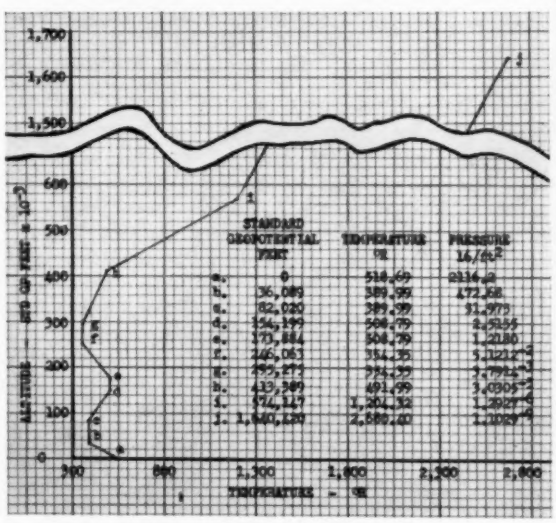

Figure 1. Abbreviated table and graph of the "1956 ARDC Model Atmosphere."

This Working Group has since made its recommendations to the parent Committee, and the Cambridge Research Center is now in the process of publishing the Data and Tables as two reports:

An Air Force Survey in Geophysics, Cambridge Research Center Technical Note entitled, "1956 ARDC Model Atmosphere."

A Government Printing Office publication entitled "The United States Standard Atmosphere," dated 1956.

Identical to U. S. Standard

These two atmosphere tables will be identical to th

**ICAO Document 7488, Manual of the ICAO Standard Atmosph Montreal, Canada, 1954.*

limit of the U.S. Standard Atmosphere. Two documents are being published instead of one because the Working Group recommended the following breakdown of the atmosphere tables, denoting levels of confidence:

"Standard Atmosphere" – From 0 to 32 Std Gp Km (Standard Geopotential Kilometers) (0 to 104,992 Std Gp Feet).

"Tentative Atmosphere" – From 32 to 75 Std Gp Km (104,992 to 246,075 Std Gp Feet).

"Speculative Atmosphere" – From 75 to 300 Std Gp Km (246,075 to 984,300 Std Gp Feet).

The "1956 ARDC Model Atmosphere" is being published to meet the Air Force requirement to extend the state of the atmosphere to even greater heights.

Publication of the "1956 ARDC Model Atmosphere" will provide the Air Force and other users of atmosphere tables a model atmosphere consistent with the Standard but extending to 500 Std Gp Km (1,640,500 Std Gp Feet). Figure 1 is an abbreviated table and graph of the "1956 ARDC Model Atmosphere."

Because we have discussed a number of different documents with regard to atmosphere tables, the notion may arise that there still is no universal standard atmosphere. However, the "1956 ARDC Model Atmosphere" and the "United States Standard Atmosphere" are consistent with the following documents up to 65,800 Std Gp Feet:

ICAO Document 7488, "Manual of the ICAO Standard Atmosphere," Montreal, Canada, 1954.

NACA Technical Note 3182, "Manual of the ICAO Standard Atmosphere Calculations by the NACA," ICAO, Montreal, Canada, and Langley Aeronautical Laboratory, Langley Field, Virginia, 1954.

NACA Technical Report 1235, "Standard Atmosphere Tables and Data for Altitudes to 65,800 Feet – 1955."

NACA Adopts Standard

The NACA officially adopted the ICAO Standard Atmosphere on November 20, 1952, and the ICAO Standard Atmosphere superseded NACA Report 218, "Standard Atmosphere – Tables and Data," as of that date. The proposed extension to the standard atmosphere was officially adopted by the United States Committee in August 1956, and consequently the Air Force is adopting the United States Standard Atmosphere 1956, for contractual work requiring standard atmosphere tables above 65,000 Std Gp Feet, up to and including 984,300 Std Gp Feet. For altitudes up to and including 1,640,500 Std Gp Feet, the "1956 ARDC Model Atmosphere" will be used.

The Air Force is not requiring contractors to recompute all performance data now on record, but for any new contract work, the performance calculations will be based on the officially adopted Standard Atmosphere Tables.

END

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Designing Test Facilities for Liquid Oxyge

NORMAN MEYERS, Stratos Div., Fairchild Engine Airplane Corp.

Storing liquid oxygen can be like carrying mercury on a fork. This article spot-lights problems facing the test engineer who must store and handle liquid oxygen in rocket test facilities...

The use of liquid oxygen with hydrocarbons as a source of high energy fuel has already come into being in the rocket industry. The resulting problems of the test equipment engineers have just begun. Handling and storage of liquid oxygen, needless to say, will require special techniques to be developed only by experience. My intention here is to point out some of the basic problems to be faced in the design of test facilities capable of handling these substances.

At ordinary temperatures it is impossible to keep oxygen liquified indefinitely because of its low critical temperature. Above the critical temperature no amount of pressure will cause it to liquify. At one atmosphere, liquid oxygen boils at −296°F. It reaches the solid state at −361°F. The critical temperature is −182°F. Therefore, liquid oxygen cannot be maintained in its liquid state for prolonged periods when the ambient temperature is greater than −182°F. For this reason the substance should never be left in a closed or unvented container. If left in such a container, a violent explosion will occur due to the tremendous pressure increases caused by the evaporating liquid.

Evaporation Losses

To cut down evaporation losses, liquid oxygen should be stored in carefully insulated containers. These vessels are most efficient when an evacuated jacket is used and is surrounded by a lagging of the insulating material Santocell. Santocell is a specially developed insulator for cryogenic applications.

Without vacuum-jacket protection, the evaporation losses in either static or dynamic conditions run about 70 percent by volume in a 24-hour period. With a vacuum-jacket, the evaporation rate is cut down to a low 1 percent by volume in a 24-hour period. The vacuum method can also be employed in the piping system. This is discusse further along in the article.

Mr. Meyers is a project engineer at Stratos with the chief duty of facility planning. He received the Bachelor of Science degree in mechanical engineering from New York University in 1947, and is a member of the American Rocket Society, the Institute of the Aeronautical Sciences, and the Institute of Environmental Engineers.

Hypothetical Case

Let us now take a hypothetical case, and go through th steps of designing a test facility. Assume that a pump capable of supplying a continuous flow of liquid oxyge under varying suction heads, and capable of developin a certain head for a missile application, is to be full proven by complete testing. This means that the te equipment engineer must be able to simulate all stati and dynamic conditions the pump will experience in missile during operation.

Now let us assume that the specifications on the pump design call for it to operate at a suction range of 50 to 10 psia, and to be capable of developing a head of 3,000 fee with an inlet temperature of −296°F. (Whether th pump is turbine or motor driven is of no concern, as thi discussion is on liquid aspects only.) Let us say that th pump must deliver 50 gpm (gallons per minute) con tinuously.

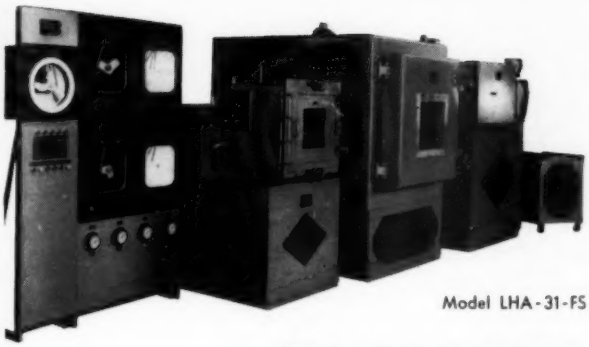
Our next approach is to analyze the complete progra and then define a specific method by which we can mee the specification. We know that a commercially obtain able storage tank is needed for the liquid oxygen itsel We know that pump suction conditions must be varie and also that the discharge must be throttled so that w can control he head. Proper instrumenation must b selected so that the entire system can be recorded an controlled. Cryogenic valves and controllers are availabl commercially to complete the basic equipment needs our facility.

Now let us go into more detail on the major proble that arise, as they are now clearly defined. First, we hav to insure the state of the oxygen — we have to maintai it as a liquid from the storage vessel through the pipin system to the test pump. Secondly, flow, pressure, an temperature must be accurately controlled.

Nitrogen Gas for Regulation

For regulating pressure and flow, nitrogen gas, which very inert, provides one of the most economical an easily controllable means.It is available in large or sma

(Continued on Page 16)



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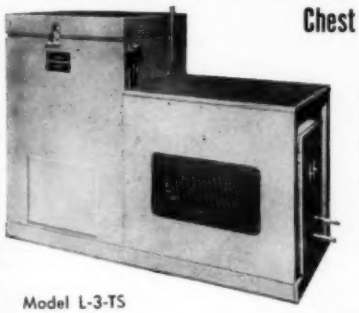

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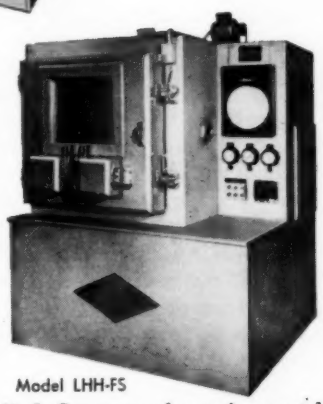

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Introducing

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This is the first in a series of thumb-nail sketches of the members of the Environmental Equipment Institute.

Tenney Engineering, Inc., is the world's oldest manufacturer of environmental equipment. It has had the longest experience in the scientific specialties and maintains a large technical and scientific staff for carrying on the basic research, development, and fabrication of environmental equipment. Tenney is a typical example of the rapid growth that has occurred in a field still in its infancy and just recently recognized as an industry — the environmental equipment industry.

In the thirties, the company applied its engineering and manufacturing experience in temperature and humidity control to urgent laboratory research and the development of prototype test equipment. The bakery equipment originally manufactured quickly gave way to the requirements of a new era. By the onset of World War II, Tenney was already engaged in high-priority production work for all of the Armed Forces requiring environmental equipment.

Of course, in those days it wasn't even designated as "environmental equipment." The user wanted "ice boxes" for low temperature, and –40°F was a very rigid specification. Failures of expensive war material and loss of precious lives made it mandatory that test units be devised, and on a crash basis. Progress in this field was steady.

After World War II the company maintained its know-how, and added considerably to plant and personnel, using the rapidly-growing commercial refrigeration division to augment its specialized engineering staff. Research in environmental fields was carried on constantly.

When the National preparedness program received sharp impetus from the Korean action, Tenney Engineering expanded again in the service of Government and industry. Today's specifications take into account extremes of high and low temperatures impossible to achieve a few brief years ago, and the outlook seems to warrant even more drastic changes.

Tenney constantly increases its plant facilities, machinery, and equipment, and its engineering, production, and service organization to satisfy the growing demand for its services. Sales in each month of 1956 exceeded annual sales in WW II days.

Just 10 years ago a handful of technical personnel could assume full responsibility for Tenney's engineering and production, reporting directly to the president, Monroe Seligman. Today Dr. Bruno Sachs, V.P., is in charge of engineering and production. A full staff of engineers work under Chief Engineer Bernard Friedman. Manufacturing is headed up by Seymour Sternbach, Manufacturing Manager. Sales development is headed up by R. H. Brown, Vice President, with a staff of sales engineers fully cognizant of field requirements, and factory-indoctrinated engineer manufacturing representatives cover the entire

(Continued on Page 20)

New Literature

News of literature of interest in the environmental field is welcomed by the editor. Send releases to the *Environmental Quarterly*, 9 Spring Street, Princeton, N. J.

Proceedings of 2nd Annual Meeting, Science Section, Environmental Equipment Institute (now the Institute of Environmental Engineers). Limited mimeographed edition being published in two volumes at $10.00 for both. Volume I available March 15th. Mailed automatically at no further cost to all who attended the Annual Meeting and to those who were members in good standing of the Science Section on or before April 20, 1956, but did not attend. Send orders to IEE, 9 Spring Street, Princeton, New Jersey.

VACUUM PUMPS

Bulletin 9. Vacuum pumps with information for the lab planning installation of high vacuum systems; price list. Central Scientific Co., EQ Div., 1700 Irving Park Rd., Chicago, Ill.
Circle 871 on Page 20.

Bulletin 5H3 describes 3-, 4-, and 5-stage Steam Jet Vacuum Pumps and Vacuum Boosters, condensing and non-condensing. Schutte and Koerting Co., EQ Div., Cornwells Heights, Bucks County, Pa.
Circle 881 on Page 20.

Catalog 752. Vacuum processing data on Stokes high vacuum pumps; specs, formulas, constants, conversion factors, solutions to pump selection problems. F. J. Stokes Corp., EQ Div., 5500 Tabor Rd., Phila. 20, Pa.
Circle 891 on Page 20.

VIBRATION ANALYSIS. Bulletin No. 124E presents pickups and meters for precise vibration analysis. Includes table of natural frequency, damping, d-c coil resistance, etc., of pickups. MB Mfg. Co., EQ Div., 1057 State St., New Haven 11, Conn.
Circle 911 on Page 20.

VIBRATION METER. Type 1-128. Displacement readings on 500-microampere meter appear calibrated in tenths to read from zero to five mils on the XI range. Bulletin 1566, Consolidated Electrodynamics Corp., EQ Div., 300 North Sierra Madre Villa, Pasadena, Calif.
Circle 901 on Page 20.

VIBRATION TESTING. Brochure. 103A Slip-Sync provides automatic synchronization of strobe lights for observing tests in slow motion. Chadwick-Helmuth Co., EQ Div., 472 E. Duarte Rd., Monrovia, Calif.
Circle 921 on Page 20.

ENGINEERING SOCIETIES DIRECTORY. Pub. by Engineers Joint Council, 29 W. 39 St., New York 18, N. Y. $3.50. Lists name, purpose, and secretary of all local, regional, and national societies.

HIGH TEMPERATURE SYMPOSIUM PROCEEDINGS. 218 pages. Stanford Research Institute, Menlo Park, Calif. $5.00.

SYMPOSIUM ON IMPACT TESTING. ASTM No. 176. 169 pp. $3.50. SELECTED ASTM ENGINEERING MATERIALS STANDARDS. 370 pages. $4.00. $1.50 to engineering college students. Includes standards and specifications for frequently-used materials and the testing methods. Am. Soc. for Testing Materials, 1916 Race St., Philadelphia 3, Pa.

LOW-FREQUENCY PROBE. Leaflet on "SonoProbe" correlator for noise or vibration measurements. Advanced Electronics, Inc., EQ Div., 94 Silas Deane Highway, Rocky Hill, Conn.
Circle 951 on Page 20.

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Circle 751 on Page 20.

STEAM JET VACUUM PUMPING

(Continued from Page 6)

parts that have to be replaced in order to maintain design capacity. Wet steam will occasionally erode the steam nozzle, but this is easily and simply replaced. Corrosion resistant jets are available if corrosive gases are to be pumped.

Rate of Climb

The rate of climb of the system depends upon the volume of the chamber and the characteristic curve (Fig. 4) for the particular jet system installed.[6] In general, the rate of climb for jet pumps is less than that for equivalent mechanical pumps up to the point where staging is required. Beyond this altitude, the jet pumps, retaining their efficiency, actually exhibit a rising rate-of-climb characteristic, that is, as the altitude increases, the rate of climb increases. This is true because the mass of gas removed from the chamber per unit of time remains relatively constant until the design point of the stage system is passed. Even in single-stage operation, the difference in pump-down time in comparison with mechanical pumps is small except in very large chambers (4,000 cubic feet or more). Where pump-down time is an important factor, an additional second-stage booster jet (Curve 4, Fig. 3) that is more efficient at lower altitudes can be installed.

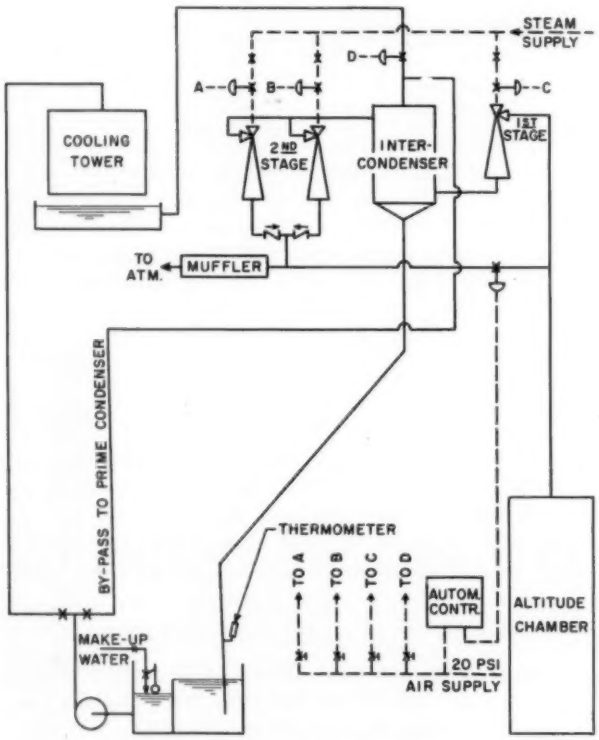
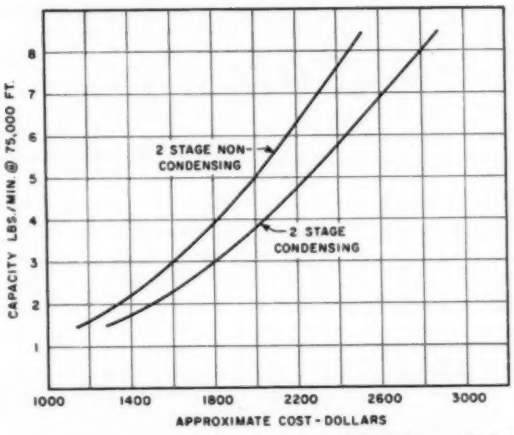


Figure 5. Simplified schematic of two-stage steam jet ejector condensing system.



Data: Courtesy the Elliott Co.

Figure 6. Comparative costs for two-stage condensing and non-condensing steam jet ejetcor systems.

It is used only during pump-out and is cut out when its own particular shut-off altitude is reached.

Future Possibilities

A steam jet system is readily adaptable for future modernization. Increased flows within the design altitude limits of a system can be obtained by paralleling jets. Higher altitudes can be obtained by three,- four- and five-step staging. Five-stage systems have been built that can develop a suction pressure of .003 inch hg, or the equivalent of about 250,000 feet altitude. In either case, the increased capacity requires only additional steam and ejectors.

Summary

A steam jet system used to simulate altitude in an altitude chamber has many advantages:

1) low first cost
2) low maintenance costs
3) high mass flows possible at high altitudes
4) little floor space required
5) can be installed outdoors
6) can accommodate any type of gas

Its disadvantages are:

1) high steam flows required
2) large quantities of cooling water required (condensing system only)
3) slower rate of climb at the lower altitudes

The actual selection of the ejector system depends upon many factors. The data presented here are intended only as a guide. Accurate definition of the chamber's requirements, plus close cooperation with the jet manufacturer will result in the best design for a particular application.

Notes

1. "Design of Vacuum Equipment," David Ettelman, *Environmental Quarterly*, second quarter 1956.

(Continued on Page 21)

NEW BOWSER EXPLOSION CHAMBER

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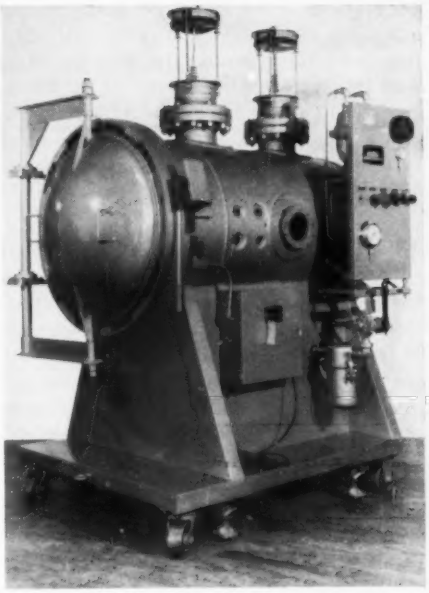

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Circle 761 on Page 20.

IEE FIRST ANNUAL MEETING

(Continued from Page 3)

"A CRITICAL ANALYSIS OF THE SALT SPRAY TEST" by Carl Durbin, Chrysler Engineering Division, and Walter Cavanaugh, Parker Rust-Proof Company

The authors will review the history of salt-spray testing, discuss standard test procedures, and present the effects of results. They will reveal data to show how salt-spray test results can be used and how they should not be used.

Session H **(Lincoln-Douglas Room): "RADIO FREQUENCY ENVIRONMENT" by W. W. Hill, Westinghouse Air Arm Division**

"RADIO NOISE TESTING" (to be announced)

(Continued on Page 19)

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FACILITIES FOR LIQUID OXYGEN

(Continued from Page 10)

quantities at pressures up to 3,000 psi, and to manifold a complete gas pressurization system with pressure reducing stations at various branches is relatively simple. This gas has a dual purpose in that not only do we vary our flow conditions, but the increase in pressure on the liquid oxygen raises the boiling point, which helps us maintain the liquid state more readily. (Assuming a pressure of 85 psia, the liquid oxygen will not boil until the temperature is increased to −280°F, as compared with boiling at −296°F at a pressure of 14.7 psia, $\triangle_t$ of 160°.

Vacuum-jacketing The Piping

Next comes the problem of vacuum-jacketing the piping from the storage vessel to the pump. This type of installation is by far the safest way of protecting the pump. This statement can be explained best as follows: if proper insulation on the piping system is not practiced, then the oxygen will vaporize in the dynamic operation of the system due to the tremendous $\triangle_t$ between the surrounding atmosphere and the piping. By the time the oxygen reaches the pump, it will have gained a temperature above the critical (−182°F) and the pump will cavitate, so we can now see the importance of vacuum-jacketing the piping system. However, this may prove too costly and not too readily obtainable. We can overcome this by doing the next best thing – sub-cooling.

A heat exchanger can be incorporated in the system between the storage vessel and the test pump. The exchanger need no be any more than a coil of pipe arranged in a serpentine design, immersed in a bath of liquid nitrogen. The bath will be used as our heat transfer medium, as its temperature at boiling is a low −320°F. This will sufficiently reduce the temperature of the oxygen as it passes through the sub-cooler, that we can be assured of its maintaining the liquid state.

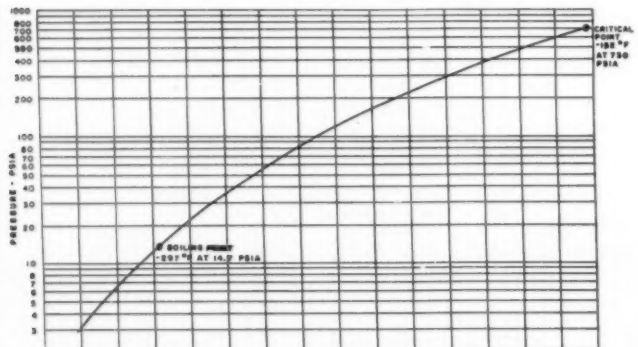

Figure 1. Vapor pressure vs. temperature.

Ample relief valves should be provided so as to allo the gases – and there will always be some – to escape t the atmosphere. It is good practice to relieve all hig points in the system.

Handling Precautions

Liquid oxygen in itself is non-corrosive and non-toxi nor is it explosive by itself, but it will support combu tion. Here is a list of handling precautions that should b followed in the operation of a facility of this type.

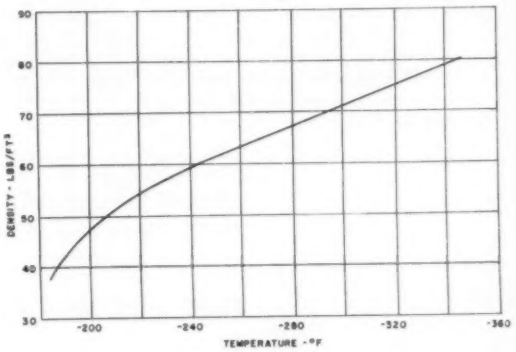

Figure 2. Density vs. temperature.

1. Do not expose oil or grease to gaseous oxygen. I you do, the mixture will explode spontaneously.

2. Do not mix oil or grease with liquid oxygen. Th mixture is explosive.

3. Loosely packed organic materials such as cloth, wast cotton and finely divided substances like aluminu powder and steel wool, mixed with oxygen burn wi explosive violence.

4. Do not smoke, and keep away from open flame sparks, and heaters. When handling liquid oxygen. Th gaseous oxygen may saturate your clothing and cau it to become highly inflammable.

5. Keep all flames and sparks away from liquid oxyg storage areas. Use non-sparking tools in these areas.

6. Do not let liquid oxygen contact any part of yo body. It will freeze flesh.

7. Do not allow gaseous oxygen to mix with vapo from any solvents (except carbon tetrachloride). Mi tures of oxygen gas with vapors of alcohol, naphtha, so vents, acetone, aniline, benzene, gasoline, kerosene, et are very highly explosive.

8. All liquid oxygen tanks should be vented to th atmosphere.

9. The complete facility should be flushed with carb tetrachloride periodically. This is to prevent the a cumulation of oil and grease, which may be inject through the liquid oxygen when charging systems.

10. Do not introduce any rubber tubing into vacuu containers, because at liquid oxygen temperatures ru

ber becomes brittle, and pieces may break off and obstruct openings.

Selection of Piping Material

In conclusion, I would like to point out that copper tubing is convenient for piping. Most materials, including some metals, become brittle at liquid oxygen temperatures and do not have the resistance to impact or sudden shock that they have at ambient temperatures. Some common materials that become brittle at very low temperatures are carbon steel, iron, and of course, plastics. The following materials are satisfactory for use at the low temperature and are arranged with the least brittle first:

1. pure nickel
2. monel
3. inconel
4. copper
5. aluminum
6. 18-8 low carbon stainless steel
7. annealed brass

EDITOR'S NOTE: Mr. Meyers offers to acknowledge all questions and comments regarding anything he has touched upon in this article.

IEE LOCAL CHAPTER NEWS

NEW YORK CITY—Lt. Col. Woodrow C. Marcus, Wright Air Development Center, addressed several hundred members and guests of the New York Metropolitan Chapter of the IEE on the subject of "Future Trends of Aircraft as Applied to Environmental Testing" on Thursday, March 7. The occasion was the Spring Dinner Meeting of the New York Chapter and the place was the Garden City Hotel, Garden City, L. I., N. Y. Host to the meeting was Stratos Division of Fairchild Engine and Airplane Company.

According to Mr. Bernard Friedman, Program Chairman of the IEE Chapter, and Chief Engineer of Tenney Engineering Inc., the highly successful meeting was attended by engineers, scientists, and others from New York, New Jersey, Pennsylvania, the New England states, and from other parts of the country.

DETROIT—The first meeting called by the Steering Committee for the Detroit Local Chapter of the IEE was held on Tuesday, February 19. The Committee is composed of Mr. Arthur Billet, Vickers Incorporated, and Mr. Charles E. Earl, Pres., Alpha Electric Refrigeration Co.

Other local chapters are now being formed in Ottawa, Canada; Los Angeles, Calif.; Boston, Mass.; Baltimore, Md.; Chicago, Ill.; and Philadelphia, Penna.

NEW YORK CITY—Mr. George O. Poyet, of the Armed Services Electro Standards Agency, spoke to the New York Metropolitan Chapter of the IEE on "The Qualification Inspection Program of ASESA" on January 24. The meeting was attended by about seventy-five members and guests.

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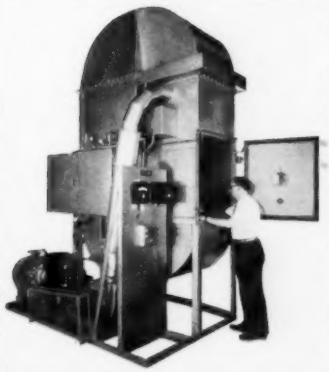
Provides simulated Altitude from sea level to 80,000 feet or higher, Temperatures from −100° F or lower to +500° F or higher, and Relative Humidity from 20% to 95%. Standard models available with rectangular test space from 5 cu. ft. to 64 cu. ft. Features include air circulation, water cooled condensers, safety thermostat.



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For testing under conditions of Sand & Dust, standard chambers are supplied with test space from 8 cu. ft. to 80 cu. ft. Streamlined design minimizes air side pressure drop. Furnished complete with initial dust supply, factory preset air velocity, and temperature, humidity, air velocity and dust density indicators.

Also manufacturers of Temperature, Humidity, Rain and Sunshine, Explosion, Fungus, Special Liquid Chilling and other types of Environmental Test Equipment.

AMERICAN RESEARCH CORPORATION
FARMINGTON 3, CONNECTICUT

Circle 771 on Page 20.

NEW PRODUCTS

News of product developments are welcomed by the editor. Send releases to the *Environmental Quarterly*, 9 Spring Street, Princeton, N. J.

CAMERA FOR HIGH NOISE ENVIRONMENTS. Kay Lab, EQ Div., 5725 Kearny Villa Rd., San Diego 11, Calif., announces a ruggedized TV camera and acoustical housing, suited for rocket and jet engine test facilities, rocket launching sites, etc. The housing provides about 45 db of isolation.

Circle 961 on Page 20.

SUBMINIATURE PRESSURE TRANSDUCER. New SLM pressure transducers, ¼ in. diameter by ½ in. long, have response time in the order of 1 micro-sec and cover a range of pressures from 0.01 to 100,000 psi. Measure steady and slowly varying pressures as well as very fast pressure transients. Available in 4 models: blast gage, shock-tube gage, ballistics gage, and hyperballistics gage. Kistler Instrument Co., EQ Div., 15 Webster St., North Tonawanda, N. Y.

Circle 971 on Page 20.

NEW "HYDRASHAKER" uses electronically actuated hydraulic power amplification; accelerations to 100G with 0.2" displacement; 20,000-lb. block force; frequency range of 5 to 2,000 cps. Wyle Mfg. Corp., EQ Div., 124 Maryland St., El Segumdo, Calif.

Circle 981 on Page 20.

STRAND BURNER to measure burning rates of explosive and jet and rocket fuels to the closest .01 sec in nitrogen atmosphere and under high pressure is offered by American Instrument Co., EQ Div., Silver Spring, Md. Four models are available with these variations in pressure ratings: 19,000; 3,000; 7,500; and 2,000 psi. Chamber where sample strands are burned is pressurized directly from commercial nitrogen cylinders for tests under 2,000 psi or by means of an oil displacement pump that compresses and stores gas in compression cylinders until needed.

Circle 991 on Page 20.

NEW "MODELS M-142B, M-191 AND M-198 ACCELEROMETERS" measure transient vibrations 10 to 80,000 cps. Reveal high-order harmonic components of vibrations and are sensitive only to axial component of vibration. Massa Laboratories, Inc., EQ Div., Hingham, Mass.

Circle 1001 on Page 20.

ROCKET FLIGHT SIMULATOR. An automatic test system that subjects devices to the acceleration and deceleration forces of rocket and missile flights. Consists of acceleration-deceleration, program, and data recording units. A device can be accelerated from 2 to 125 g's in 200 milliseconds. Minimum braking time, 100 milliseconds. Maximum flight time, 55 sec. The Magnavox Co., EQ Div., Fort Wayne 4, Ind.

Circle 1021 on Page 20.

MATERIAL SURVIVES 3,000 F FOR 10 MIN. Test firings of rocket motors using a new high-temperature resistant material – phenolic resin and asbestos – as a liner have subjected the material to 3,000 F temperatures for 10 minutes without failure. This material, molded over a form in an autoclave, has no restriction on the shape that can be produced, and the autoclave will handle pieces up to 10 feet in diameter and 12 feet high. The material can be machined like brass, the company says, but carbide tipped tools are needed. Cutting is done with diamond saws. Tensile strength is estimated at about 30,000 psi. with glass reinforcing. Specific gravity is 1.8. Cost of a tube liner 5½-in. diameter by 8 feet long – about $200. Haveg Industries, EQ Div., Wilmington 8, Del.

Circle 1031 on Page 20.

Designed and built for GREER HYDRAULICS, Inc. NEW YORK

IRE SHOW BOOTH 1225

ALSO CHAMBERS FOR...

- VACUUM OVENS
- HUMIDITY
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- WALK-IN ROOMS
- LIQUID HOT & COLD BATHS

Walk-in Room interior dimensions — 10' x 10' x 8' high. Removable temperature partition. Each of the two sections can be operated at different temperatures. Temperature range −100°F. to +400°F. — Altitude — can be built to 100,000 feet or higher. — Separate air lock for entrance of personnel without upsetting altitude run. — Rain in either or both compartments at rate of 4" per hour. — Humidity — 20% to 100%. Chamber constructed sectionally for ease of installation.

ENVIRONMENTAL TEST EQUIPMENT

INTERNATIONAL RADIANT CORPORATION
40 Matinecock Ave., Port Washington, N. Y

Circle 781 on Page 20

IEE FIRST ANNUAL MEETING

(Continued from Page 15)

TECHNICAL MEETING COMMITTEE

CHAIRMAN
S. Danko
Motorola Incorporated

MEMBERS

R. Amorosi	**Parameters, Incorporated**
H. Jones	**Westinghouse Air Arm Division**
H. Sander	**Vapor Heating Corporation**
R. Stallard	**Glenn L. Martin Company**
G. D. Wilkinson	**General Manager, IEE**

EQUIPMENT CONFERENCE COMMITTEE

N. Miller	**Murphy & Miller, Inc.**
R. Jamison	**Cincinnati Sub-Zero**

The "T PLOTTER" developed by Insco Div. of Barry Controls, Watertown, Mass., plots a complete vibration transmissibility curve in strip-chart form during the vibration test cycle for immediate evaluation of equipment performance by design and laboratory engineers. It is an automatic and continuous ratio plotter and saves 50 to 75 percent of vibration lab testing time.

For more information, circle 702, p. 20.

IEE SPONSORS TOUR OF CHICAGO UNIVERSITY RESEARCH LABORATORIES

The two facility trips included on the program of the Institute of Environmental Engineers Annual Meeting will take groups into the famous laboratories of the Fermi Institute for Nuclear Studies and the Institute for the Study of Metals at the University of Chicago. Certain tests will be conducted for the benefit of the touring groups. The low-temperature laboratory of the Institute for the Study of Metals is one of the two largest installations in the United States for the production of liquid hydrogen and liquid helium.

GOODYEAR BUILDS RADIATION LAB

A new radiation laboratory, reportedly the first of its kind in the rubber industry, was opened recently by the Goodyear Tire and Rubber Company, Akron, Ohio.

The new lab is designed for the development of rubber products that will stand up in a radiation environment. The source of radiation is to be radioactive cobalt 60, which gives off high-energy X-rays or gamma rays.

One of the more important projects planned is development of radiation-resistant tires that could be used on atomic-powered aircraft.

LOW-TEMPERATURE SYSTEMS

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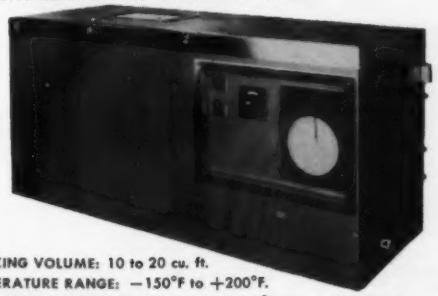
HEAVY-DUTY, CHEST-TYPE UNITS FOR METALWORKING INDUSTRIES — APPLICATIONS IN HARDENING, STABILIZING AND SHRINK-FITTING.



WORKING VOLUME: 10 to 20 cu. ft.
TEMPERATURE RANGE: −150°F to +200°F.
TEMPERATURE CONTROL TOLERANCE: ±1°F over entire range.
COOLING CAPACITY: 1500–3000 BTU/hr at −150°F.
DIMENSIONS: 42" high, 36" wide, 80" to 120" long.

Rugged chest construction, honeycombed double liners of welded steel, and rimmed stainless-steel top combine to withstand the wear and tear of heavy usage.

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Circle 791 on Page 20.

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701	751	811	871	951	1011
702	761	821	881	961	1021
711	771	831	891	971	1031
721	781	841	901	981	
731	791	851	911	991	
741	801	861	921	1001	

First Quarter, 1957

TENNEY ENGINEERING

(Continued on Page 12)

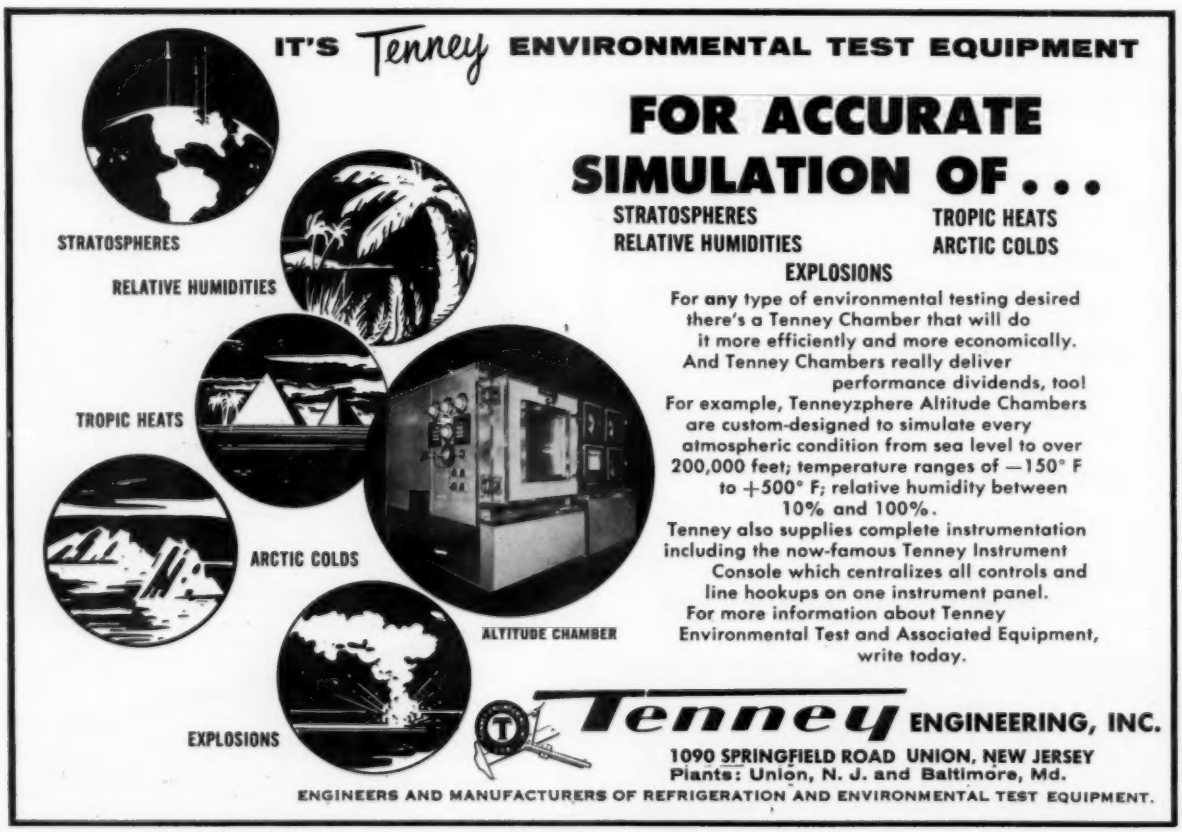
country. Saul Schiffman, Treasurer, completes Tenney's top management team.

Environmental equipment is manufactured at the Union, New Jersey, plant, built in 1953 under a government certificate of necessity. The Baltimore plant manufactures refrigeration equipment and some components for Union.

The new building in Union stands on almost 7 acres of land, is completely sprinklered, and has 18′ high ceilings with clear spans of 40′ in order to accommodate larger equipment needed for today's programs.

Tenney Engineering, Inc., officials have every confidence that the next ten years will see advancement in techniques and scope unknown today. The Company pledges its efforts toward continued research to maintain the level of this industry far above that of any foreign power.

IEE First Annual Meeting, La Salle Hotel, Chicago, April 25 and 26. Program announcement on page 2. Hotel reservation card enclosed with this issue of the Quarterly.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FOR ACCURATE SIMULATION OF . . .
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ARCTIC COLDS
EXPLOSIONS
For any type of environmental testing desired there's a Tenney Chamber that will do it more efficiently and more economically. And Tenney Chambers really deliver performance dividends, too! For example, Tenneyzphere Altitude Chambers are custom-designed to simulate every atmospheric condition from sea level to over 200,000 feet; temperature ranges of —150° F to +500° F; relative humidity between 10% and 100%.
Tenney also supplies complete instrumentation including the now-famous Tenney Instrument Console which centralizes all controls and line hookups on one instrument panel.
For more information about Tenney Environmental Test and Associated Equipment, write today.
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Plants: Union, N. J. and Baltimore, Md.
ENGINEERS AND MANUFACTURERS OF REFRIGERATION AND ENVIRONMENTAL TEST EQUIPMENT.

Circle 811 on Page 20.

STEAM JET VACUUM PUMPING

(Continued from Page 14)

2. "Rotary Compressors and Vacuum Pumps," W. L. Bruce and W. A. Schubert, *Chemical Engineering*, June 1956.

3. NACA (National Advisory Committee for Aeronautics) Technical Note 1120, used for all altitude-pressure relationships.

4. "Controlling Ejector Performance," C. G. Blatchley, Schutte-Koerting Company, Bulletin 10-56.

5. "Steam Jet Ejector Handbook," W-205-E21, Worthington Corporation.

6. To calculate the time to pump out a given chamber to a pressure p2 the following applies:

t_2 = time in seconds
T = absolute temperature of chamber air °F (assumed constant)
V = volume of the chamber ft^3
R = gas constant; for air, R = 53.3
W = rate of flow, lbs/sec
dp = instantaneous change in chamber pressure, lbs/ft^2

$$t_2 = -\frac{V}{RT}\int_{p1}^{p2}\frac{dp}{w} \quad (T = \text{constant})$$

The characteristic curve of the jet system is W as a function of p (Fig. 4). If this curve is replotted to $\frac{1}{W}$ as a function of p, then the area under this new curve from p1 to p2 represents the value of the integral in the above equation. END

BEMCO EXPANDS

BEMCO, Inc., has recently doubled its Engineering and manufacturing facilities by moving to a new and larger plant at 11631 Vanowen Street, North Hollywood, California. Warren R. Bruskrud, President, announced that this will permit BEMCO, Inc., to expand activities in the design and manufacture of environmental test facilities and equipment.

According to Mr. Bruskrud, there is an increasing demand for test facilities that simulate the extremes of altitude, temperature, humidity, and other environmental conditions.

HUDSON BAY CO.

MANUFACTURERS OF LOW TEMPERATURE AND ENVIRONMENTAL EQUIPMENT SINCE 1941

Test equipment manufactured for the above environmental conditions available in sizes from one cu. ft. to 40 cu. ft. "CUSTOM" Chambers, Liquid Baths, Chillers, Rooms, manufactured to specification.

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Standard Units for:

★ Low Temperature, Minus 120°F

★ High Temperature, Plus 1000°F

★ Humidity & Temperature, 20% to 95%, 32°F to 200°F

★ Altitude, 100,000 Ft. and 350,000 Ft.

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Circle 801 on Page 20.

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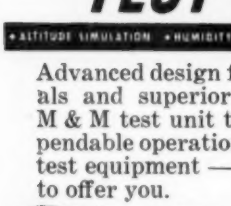
Advanced design features, highest quality materials and superior craftsmanship go into every M & M test unit to assure accurate tests and dependable operation. Before you specify or buy *any* test equipment — see what Murphy & Miller has to offer you.



MODEL LTA 12
12 CUBIC FT. TEST SPACE

ALTITUDE SIMULATION UNIT

- **Altitude Ranges over 200,000 ft.**
- **Temperature Range from +1200°F to —120°F**
- **Humidity cycle 20% to 95% from +35°F to 185°F**
- **New design — greater capacity per horsepower — lower operating cost . . . greater efficiency**

Available in units with 12 to 64 cubic ft. of test space, M & M Altitude Simulation Chambers offer every standard and optional feature for faster, more flexible testing. Optional features include Program Controlled Heating, Cooling and Humidity Cycles, Automatic Recorders, Special Wiring, etc. etc.

MODEL H 12
12 CUBIC FT.
TEST SPACE

HUMIDITY TEST CABINET

- **Provides Relative Humidities between 20% and 95%**
- **Temperatures from +185°F to —35°F**
- **Instant response of humidity system insures accurate testing**
- **Uniform temperature and humidity throughout test cycles.**

High capacity heating, refrigeration and forced air systems insure fast, accurate temperature rise and pull-down Program control cycle for temperature, humidity and cooling available. Models manufactured with test spaces to 64 cubic feet.

DRY ICE FUNGUS HUMIDITY

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- **Exclusive sloping front for easier viewing . . . faster loading**
- **Available in single units or combinations**

Compact, portable and inexpensive, M & M Slope Front test cabinets are made for low temperature (dry ice refrigerant) Fungus, humidity testing. Cabinets are fully automatically controlled.

Write for illustrated literature and complete specifications.

MURPHY & MILLER, Inc.
1322 So. Michigan Avenue · Chicago 5, Illinois

Circle 821 on Page 20.

— CALENDAR —

MARCH

10-13	Am. Inst. of Chem. Engineers, Greenbriar Hotel, Whi Sulphur Springs, Va.
11-15	1957 Nuclear Congress and International Atomic Expos tion, sponsored by several technical groups, Conventio Hall, Philadelphia.
14	Gas Dynamics Colloquium, "Turbulent Diffusion Gases," Tech. Inst., Northwestern Univ., Evanston, I
14-15	Flight Propulsion Meeting (Classified), sponsored by IA Hotel Carter, Cleveland, O.
14-16	Military-Industrial Conference, sponsored by The So of Am. Military Engineers, Conrad Hilton Hotel, Chicag Contact D. A. Sullivan, 72 W. Adams St., Chicago 90.
18-19	Steel Founders Soc. of Am., 55th annual meeting, Dra Hotel, Chicago.
18-21	IRE National Convention, Waldorf-Astoria Hotel, Ne York City Coliseum.
18-21	First Military Automation Exposition, New York Trad Show Bldg., 500 8th Ave., New York City. For informatio write R. Rimbach Associates, 845 Ridge Ave., Pittsburg 12.
18-21	National Conference and Pacific Coast Plastics Expos tion, The Soc. of The Plastics Industry, Inc., Biltmor Hotel and Shrine Exposition Hall, Los Angeles.
21-23	Div. of High-Polymer Physics, Am. Physical Soc. meetin Univ. of Penn., Philadelphia. Contact Dr. L. Mandelker Polymer Structure Sect, National Bureau of Standard Washington 25, D.C.
25-27	Am. Soc. of Tool Engineers, 25th Annual Meeting, Sham rock-Hilton Hotel, Houston.
25-29	10th Western Metal Exposition and Congress, Am. So for Metals and others, Ambassador Hotel and Pan-Pacif Auditorium, Los Angeles.
27-29	Colloquium on Radiation Effects on Materials, sponsore by the office of Naval Research and the Glenn L. Marti Co., at Johns Hopkins Univ., Baltimore.

APRIL

1-2	5th Midwest Conf. on Fluid Mechanics and the 3rd Mid west Conf. on Solid Mechanics, concurrently at the Univ of Michigan, Ann Arbor.
2-5	SAE Aeronautic Meeting and Production Forum, Ne York City.
3-5	Southern District Meeting, Am. Inst. of Electrical Engi neers, Hotel Heidelberg, Jackson, Miss.
3-6	American Rocket Soc., Spring meeting, Sheraton-Par Hotel, Washington, D.C.
4	Gas Dynamics Colloquium, "A Spherical Shock Tube Tech. Inst., Northwestern Univ., Evanston, Ill.
7-12	Am. Chem. Soc., National Meeting, Miami.
8-10	Spring Meeting, ASME, Dinkler-Tutwiler Hotel, Birm ingham, Ala.
8-11	British Radio and Electronic Component Show, Grosvenc House and Park Lane House, London, England.
9-10	Annual Industrial Electronics Educational Conf., IRE Armour Research, Ill. Inst. of Tech., Chicago.
11-13	9th Southwestern IRE Conf. and Electronics Show, Sham rock-Hilton Hotel, Houston 1.
14-16	IRE National Symposium on Telemetering, Philadelphia
16-18	Symposium on Nondestructive Tests in the Field o Nuclear Energy, Morrison Hotel, Chicago.
24	**Environmental Equipment Institute, Annual Meeting La Salle Hotel, Chicago. (Not open to the public.)**
24	*Federal Trade Commission Conference, trade practic rules for environmental equipment industry, Chicago.*
24-25	2nd National Industrial Research Conf., sponsored b Armour Research Foundation, Conrad Hilton Hotel Chicago.
25-26	**Institute of Environmental Engineers, Annual Tech nical Meeting, La Salle Hotel, Chicago. See page 2 for program.**

DIRECTORY OF IEE MEMBERSHIPS

A list of those who have joined since the last issue of the Environmental Quarterly.

MEMBERS

California

MAX A. PAPE, Missile Development Div., No. Am. Aviation, Downey

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EVERETT O. BRAATEN, PSC Applied Research Ltd., 1500 O'Connor Drive Toronto 16, Ontario

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District of Columbia

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LEWIS F. MALCOLM, JR., ACF Industries Inc., 508 Kennedy St., N.W., Washington 11

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GEORGE G. BROWN, Inland Testing Labs., Div. Cook Electric Co., 6401 W. Oakton St., Morton Grove

DARL R. GOLDEN, Barber Colman Co., Rock St., Rockford

Maryland

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JAMES J. KERLEY, JR., Westinghouse Electric Corp., Air Arm Div., Baltimore

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LAURANCE HURLEY, AVCO Research & Advanced Devel. Div., 16 Shackford Rd., Reading

GERALD A. JENSEN, AVCO Mfg. Corp., Research & Adv. Devel. Div., 20 Union St., Lawrence

EDWARD G. LEBRE, Laboratory for Electronics, 75 Pitts St., Boston 14

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EDWIN F. CAPE, Alpha Electric Refrig. Co., 1115 E. 7 Mile Rd., Detroit 3

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FRANK KEENA, G-V Controls Inc., 45 Hollywood Plaza, E. Orange

GEORGE M. WHEELER, Tenney Engineering, Inc., 1090 Springfield Rd., Union

EDWARD T. GANNON, Weston Electrical Instr. Corp., 614 Frelinghuysen Ave., Newark 5

ROBERT BROWN, Tenney Engineering, Inc., 1090 Springfield Rd., Union

JAMES H. DYNE, Steiner-Ives Co., Springfield Rd., Union

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MONROE SELIGMAN, Tenney Engineering, Inc., 1090 Springfield Rd., Union

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SEYMOUR B. STERNBACH, Tenney Engineering, Inc., 1090 Springfield Rd., Union

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EUGENE L. BRAND, Avien, Inc., 58-15 Northern Blvd.. Woodside

JOHN J. HAMRICK, IBM, Testing Lab., Dept. 800, Endicott

ROBERT L. WEISS, IBM, Testing Lab., Dept. 800, Endicott

Ohio

DONALD F. BONHARDT, North American Aviation, Inc., Columbus Div., 4300 E. 5th Ave., Columbus 13

THEODORE J. FREDERICK, Cincinnati Sub-Zero Products, 3932 Reading Rd., Cincinnati 29

ROBERT E. SCHROEDER, Cincinnati Sub-Zero Products, 3932 Reading Rd., Cincinnati 29

Pennsylvania

ROBERT M. COOK, Amer. Car & Foundry Div., ACF Industries, Inc., Berwick

Texas

JOHN DARROUZET, Texas Instruments, Inc., 6000 Lemmon Ave., Dallas

COMPANY MEMBERS

INLAND TESTING LABORATORIES, Div. Cook Elec. Co., 6401 W. Oakton St., Morton Grove, Ill.

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HQ 4925TH TEST GROUP (ATOMIC), Kirtland Air Force Base, N. M.
Oscar E. Hopkins

OFFICE, CHIEF OF RESEARCH & DEVELOPMENT, Dept. of the Army, Washington, D. C.
William J. Ellenberger

NAVAL SUPPLY, RESEARCH & DEVELOPMENT FACILITY, Naval Supply Depot, Bayonne, N. J.
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Specially-built, custom-designed units can also be furnished for specific programs, complete with fully automatic controls. Their flexibility offers an accurate method of simulating varying conditions for pre-set time intervals. For complete details, write us and outline your testing requirements.

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Cincinnati Sub-Zero Products

General Offices and Plant
Reading Road at Paddock Cincinnati 29, Ohio

Member Environmental Equipment Institute

Circle 831 on Page 20.

Letters to the Editor

(Continued from Inside Front Cover)

be increased to 65° to 71°C (149° to 160°F). Increasing the ambient temperature of an explosive mixture also increases the rate at which an explosion will be propagated. This means that the pressure build-up in the test chamber will be more rapid, thereby requiring that pressure relief valves be of maximum sensitivity. Pressures up to 150-160 psi may be encountered practically instanteously.

An instance has been reported in which a commercially-operated explosion chamber was damaged during a test in accordance with the interim procedure, due to sluggish operation of pressure relief valves.

In consequence of the foregoing, the following recommendations are made, relative to explosion test chamber design.

a. The utilization of an improvised or locally constructed test chamber is not advisable. The chamber should be of approved commercial design, with a strength safety factor of at least 5.

b. The chamber should be equipped with at least three relief valves in accordance with USAF Drawing No. 54D6182, or equal. This design permits a pressure less than that internal to the chamber to be maintained on the outer side of the valve disc, thereby greatly increasing sensitivity and speed of operation.

c. Consideration should be given to provision for r
mote control of the test chamber in future installatio

Additional information will be provided when resear
work on the general subject of explosion proof testing
is completed by WADC.

J. R. GRIMM
Asst. Ch, Environmental Criteria I
Prod Cont Div, Opns Off
Directorate of Development
Wright Air Development Center

Dear Sir:

At the 24th Shock and Vibration Symposium, D
Weller of NAMTC, Point Mugu, advocated to the a
sembled delegates a broadening of the objectives of th
group to include studies of the practicality and effec
of combined simulated environments on missiles an
equipment. Since an undertaking such as this on a broa
scale would more logically fall within the province
the Institute of Environmental Engineers I suggest th
be considered as the theme for a future symposium.

J. E. ALLEN, Supv. Eng.
Environmental Engrg.
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BEMCO INC.

ENVIRONMENTAL TEST EQUIPMENT DESIGN AND MANUFACTURE

The BEMCO Line of semi-standardized equipment combines economy of manufacture with flexibility of control, performance and configuration.

F Series: Refrigeration and Heating, —125F to 1200 F.
W Series: Humidity controlled by Spray and/or Steam.
A Series: Altitude-Vacuum Chambers, 300,000 feet+.
WF, FA and WFA Series: Combinations of the above.
DF Series: Dry Ice Cooled, Electrically Heated.
FU Series: Fungus Chambers for MIL-E-5272 tests.
S&R Series: Duplicating natural sunshine and rain.
EX Series: Explosion testing with safety.

BEMCO Inc. is an acknowledged leader in the Development, Design, Manufacture and Servicing of quality equipment. With recently doubled manufacturing facilities, BEMCO now provides an even more complete service to the Western States.

WFA SERIES
ALTITUDE-TEMP-HUMIDITY CHAMB

WF SERIES
HUMIDITY-TEMP CHAMBER

11631 VANOWEN STREET • NORTH HOLLYWOOD, CALIFORNIA • MEMBER OF THE E.E.I. • BEMCO

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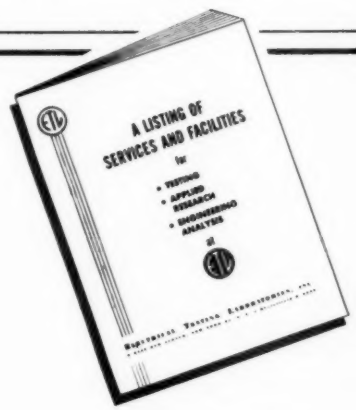
Need Testing Help?



To help you and your management explore the possibilities for relief from your engineering problems, ETL has just prepared a listing of services and facilities. It is yours for the asking

You may find your answer here, because **Testing for Industry** has been our business for nearly 60 years. We have excellent equipment and competent, thorough, experienced men who know how to use it.

You may use our talent and facilities to supplement your own effort, or for a complete testing program. In either case, the service is independent, impartial, and as confidential as your own.

We can determine properties, characteristics, and performance of the materials, apparatus, or components you use or produce — in the following fields:

Electrical and Electronic
Physical and Mechanical
Chemical and Environmental

Using E.T.L. services is like finding extra trained talent and extra test equipment without adding to your payroll or capital investment.

Know by ETL *Test*

ELECTRICAL TESTING LABORATORIES, INC.

2 East End Avenue at 79th Street • New York 21, N. Y. • BUtterfield 8-2600

CHEMICAL • ELECTRICAL • ELECTRONIC
PHYSICAL • MECHANICAL • ENVIRONMENTAL

TESTING • INSPECTION
CERTIFICATION

INCLUDING INFRARED SPECTROSCOPY, PHOTOMETRY, RADIOMETRY, SPECTROPHOTOMETRY AND PHOTOMICROGRAPHY

Circle 851 on Page 20.

ENGINEERED TESTING

ENVIRONMENTAL TESTING

Test equipment for the following environmental conditions is available in the laboratory as follows:

VIBRATION:	600# force; 2000 cps
ACCELERATION:	50# @ 50 g's
SHOCK:	Per Spec. 7201
TEMPERATURE: & HUMIDITY:	200°F 100% R. H.
TEMPERATURE: & ALTITUDE:	−100°F to +200°F 100,000 ft.
HIGH TEMP.:	To 1,000°F
RAIN:	4" per hour
SUNSHINE:	Per MIL-E-5272A
EXPLOSION:	Per MIL-E-5272A
FUNGUS:	Per MIL-E-5272A
SALT SPRAY:	Per MIL-E-5272A
SAND & DUST	Per MIL-E-5272A

All environmental equipment is suitably instrumented with recording, indicating and controlling devices and fully complies with the requirements of the Military Specification MIL-E-5272A.

FUNCTIONAL TESTING

Supplementing the normal services of an environmental test facility, Parameters, Inc. is capable of functionally testing all components. Parameters, Inc. maintains a complete hydraulic, electronic and mechanical test facility to provide a 'one-stop' testing organization.

HYDRAULIC PUMPING UNITS

Flows to 100 gpm
Pressure to 5,000 psi dynamic
30,000 psi static
Fluids JP-4, JP-5, Varsol MIL-O
OS45 MIL- -7808

PRIME MOVERS

Power from 1/20 to 160 HP
trolled variable speeds.

HYDRAULIC IMPULSE

Per MIL-5512-A

ELECTRICAL POWER

400 amp, 3 phase, 60 cps; 2
d-c; 400 cps.

INSTRUMENTATION — General electronic test equipment,
ing recorders, oscilloscopes, meter
oscillators. Transducers including
meters, pressure transducers, t
couples and potentiometers.

SPECIAL EQUIPMENT — Specialized equipment for testing
hydraulic closed loop systems in
variable gain servo-amplifier, sine
generator, phasemeter, servo valv
rotary and rectilinear potentiomete

FOR MORE INFORMATION ABOUT THE TESTING, ENGINEERING, DESIGN OR DEVELOPMENT FUNCTIONS OF PARAMETERS, INC., WRITE TO:

PARAMETERS, inc.

195 HERRICKS ROAD
NEW HYDE PARK
NEW YORK
Pioneer 6-0155

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